Unbalanced Power Sharing Control Method for an Islanded Microgrid

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Abstract

This research investigates the impact of unequal feeder lines and unbalanced loads on power sharing in AC islanded microgrids (MGs). Isolated MG technologies enable growth in consumption and improved supply security when multiple distributed sources supply shared loads. This control has benefits over other methods since it does not require communication links between the sources and does not require knowledge of feeder line models. However, the control performance degrades when the shared load is unbalanced and when the feeder lines are unequal. A control structure is proposed using reference frame theory that couples active and reactive power regulation to power metrics derived from estimated symmetrical component powers.

Introduction

Researchers have investigated the design, operation, and control of MGs particularly in islanded mode. Numerous studies have proposed hierarchical control techniques to manage power sharing between distributed generators (DGs) and MGs. This hierarchical control is typically divided into three levels as shown in Figure 1. To increase MG system capacity, the DGs are interconnected to share power to common load. In this case, ineffective power sharing among DGs causes unequal power sharing that may damage the DG source.

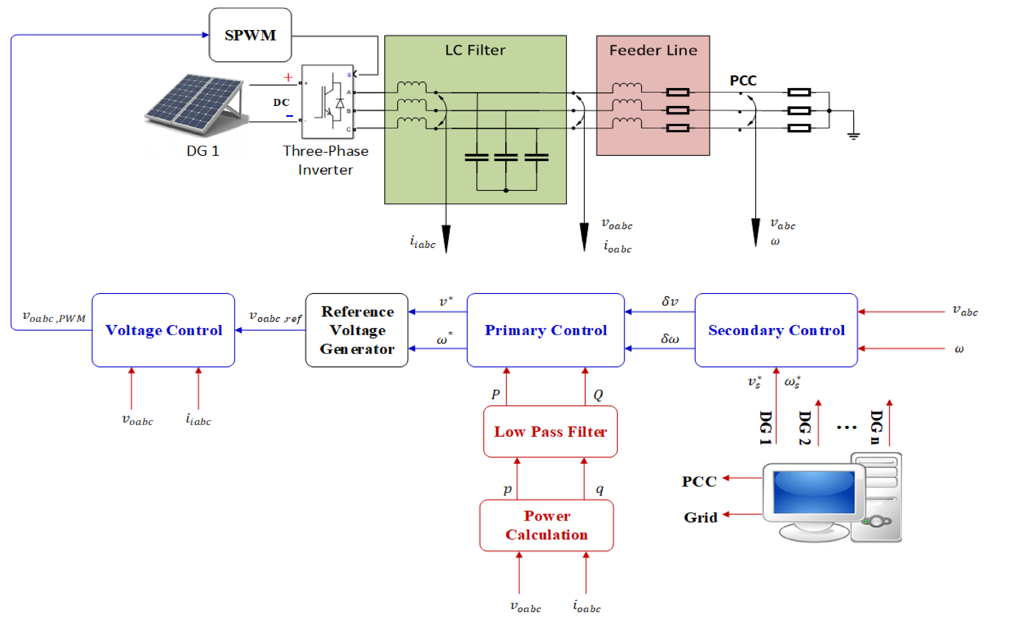

Figure 1: A hierarchical grid-forming control scheme.

Problem Statement

Effective power sharing enables growth in consumption and improved supply security when multiple DGs are interconnected with feeder lines to shared loads (Figure 2). Unequal feeder lines results in unequal power sharing and unbalanced loads further compromise performance and overall MG stability.

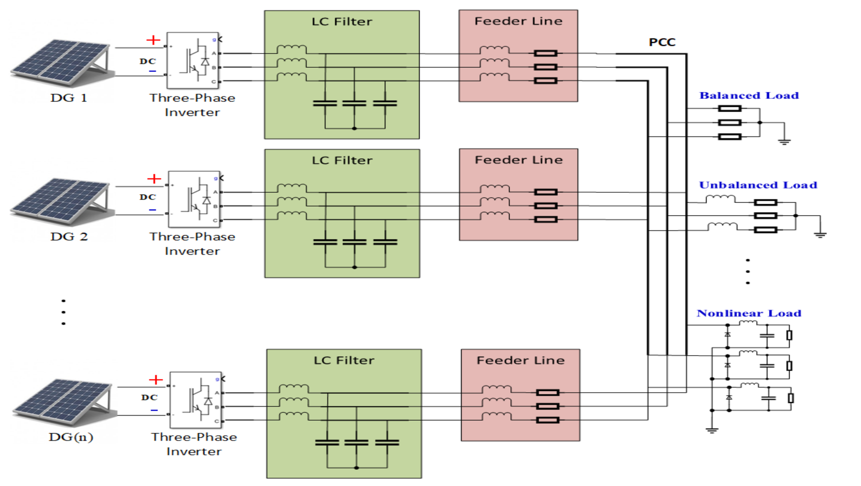

Figure 2: General power sharing in islanded microgrids.

Control Methods

This control is designed to manage active, reactive, and apparent unbalanced power sharing. The control does not require feeder line knowledge nor any inter-DG communication link. Figures 3 and 4 outline the control structure developed in the *dq*-reference frame with symmetrical component adaptations.

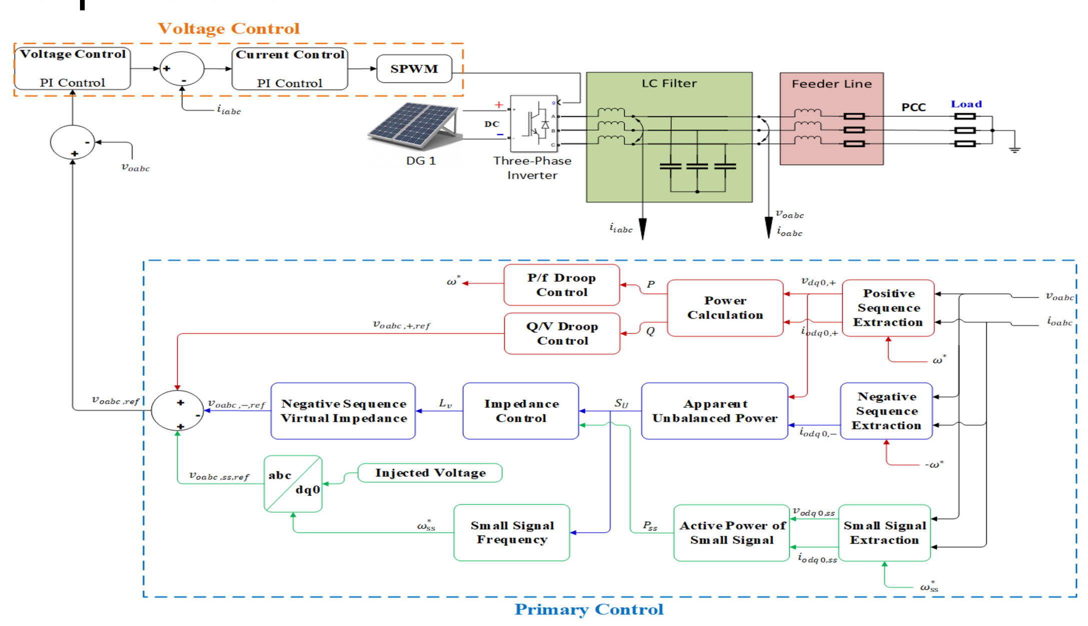

Figure 3: Structure of the proposed control method.

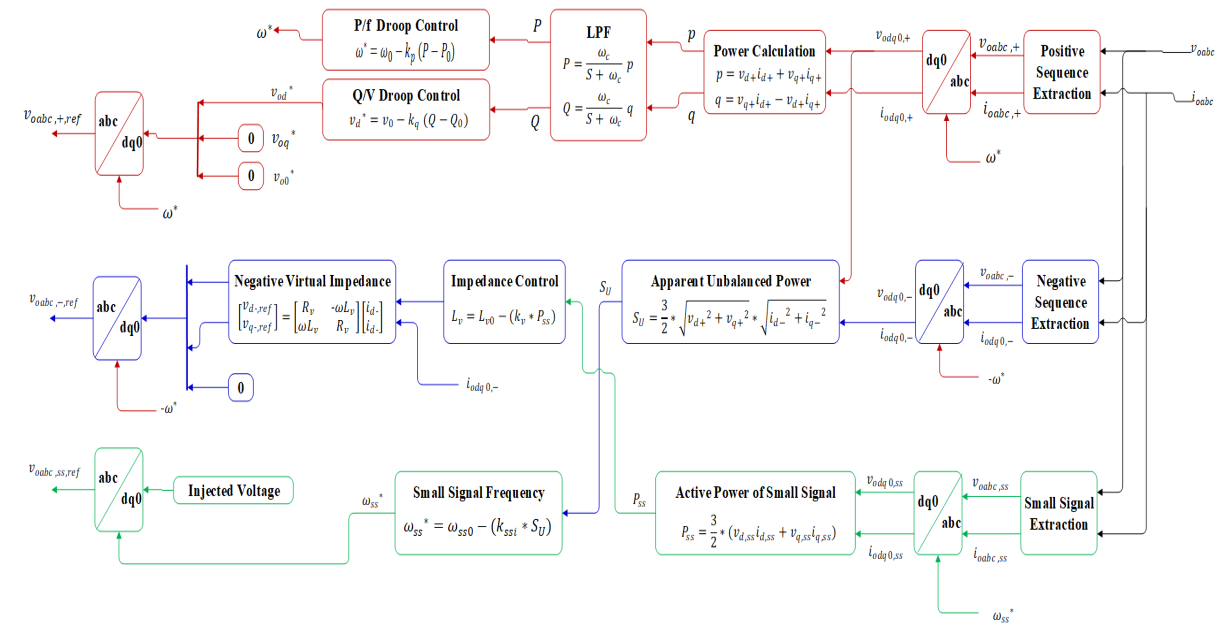

Figure 4: The primary control with mathematical details.

Simulation Results

The islanded MG model consists of two DGs and a local common three-phase shared load (Z_L). Table 1 provides the AC islanded MG parameters. The control was simulated to validate the proposed method under different conditions.

Table 1: The AC islanded microgrid parameters.

Case	DG	R_{FL1}	R_{FL2}	L_{FL1}	L_{FL2}	Z_L
1	$700\ V$	$0.1\ m\Omega$	$0.1\ m\Omega$	$1\ mH$	$1\ mH$	$10\ \Omega$
2	$700\ V$	$0.1\ m\Omega$	$0.1\ m\Omega$	$1\ mH$	$3\ mH$	$Z_a = 20\ \Omega$ $Z_{b,c} = 10\ \Omega$
3	$700\ V$	$1\ \Omega$	$3\ \Omega$	–	–	$10\ \Omega$

Unequal Inductive Feeders

Case 1: Balanced Load

The control successfully demonstrates active and reactive power sharing.

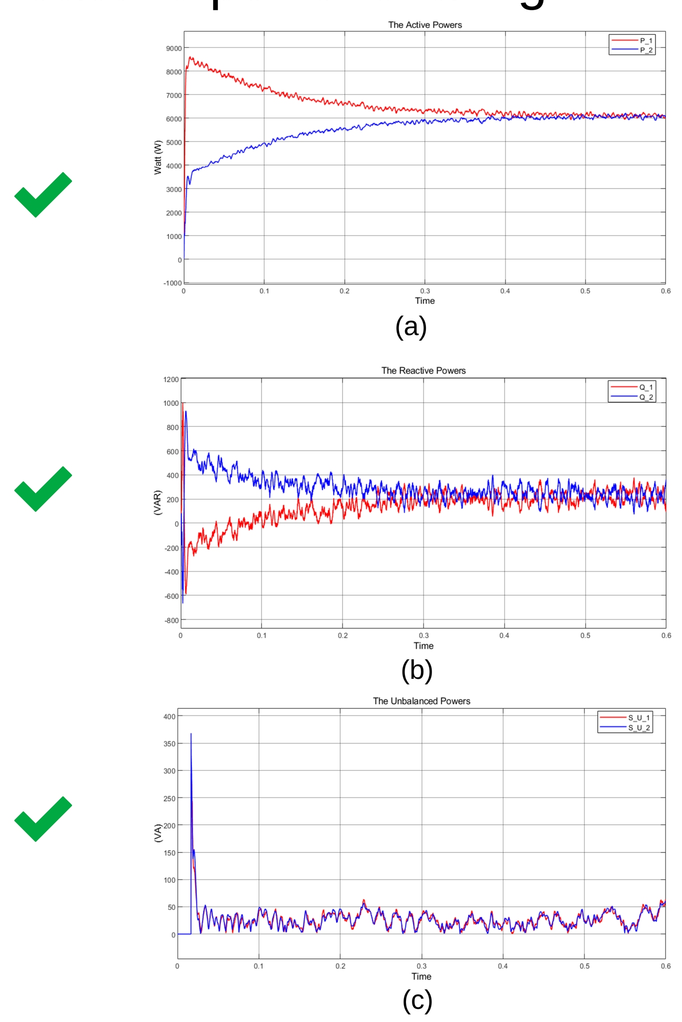

Figure 5: (a) active, (b) reactive, and (c) apparent unbalanced powers.

Case 2: Unbalanced Load

Reactive power sharing is negatively impacted with load imbalance.

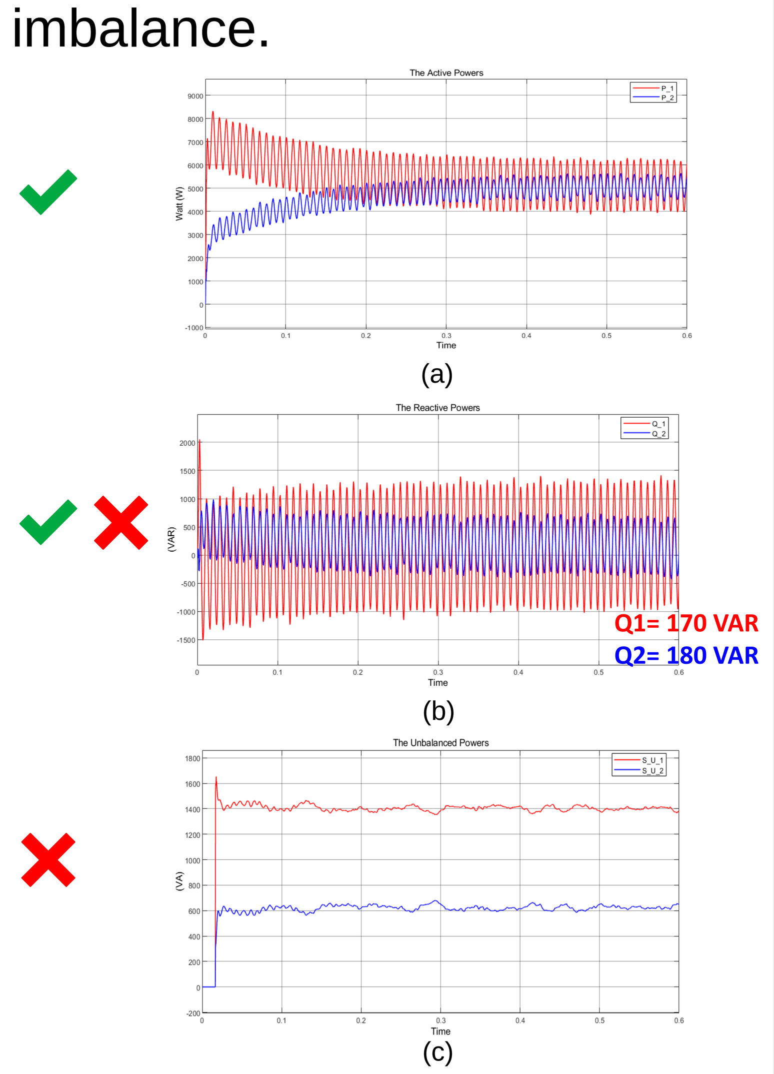

Figure 6: (a) active, (b) reactive, and (c) apparent unbalanced powers.

Unequal Resistive Feeders

Case 3: Balanced Load

Active and reactive power sharing degrade with resistive feeder lines.

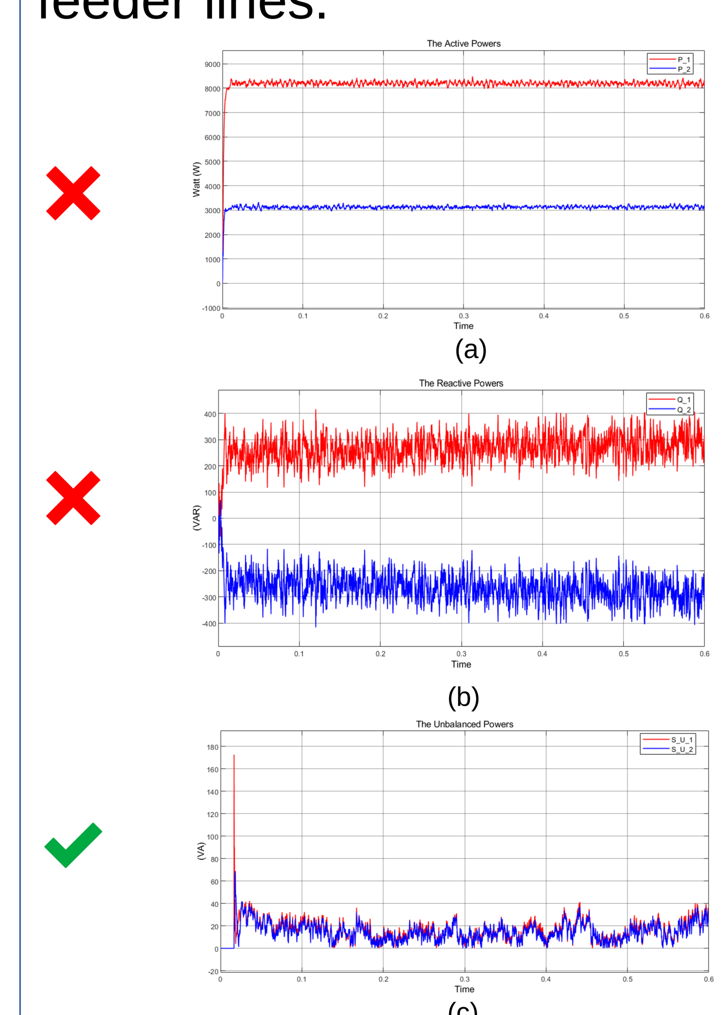

Figure 7: (a) active, (b) reactive, and (c) apparent unbalanced powers.

Conclusions

The proposed control ensures power sharing with unequal feeder lines but fails to effectively manage unbalanced power in an unbalanced load condition. In addition, the control successfully eliminates the effectiveness of unequal resistive feeder lines but fails to share active and reactive powers even in a balanced load condition.

Future Research

A new control design is needed to ensure active and reactive power sharing with resistive or unknown feeder lines. Furthermore, a global secondary control is needed to manage unbalanced power caused by a shared unbalanced load.

References

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